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AN
ACCOUNT
OF THE
COMMENCEMENT AND PROGRESS
IN
SINKING WELLS,
AT
Sheerness, Harwich and Landguard Fort,
FOR SUPPLYING THOSE
DOCK-YARDS AND GARRISONS
WITH
FRESH WATER.

TO WHICH IS ANNEXED,
THE CORRESPONDENCE
BETWEEN THE
MASTER-GENERAL OF THE ORDNANCE AND THE
COMMANDING ENGINEER OF THOSE PLACES,
(SIR THOMAS HYDE PAGE,)
UPON THE SUBJECT,
In the Years 1778, 1781, and 1783.

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ANSWER

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A N

A C C O U N T,

&c.

THIS subject was first taken into consideration by Lord Townshend, then Master-General of the Ordnance, and Captain Page, the engineer of the coast district, with a view to remove so great an objection as the want of wholesome fresh water where dock-yards and garrisons were established. A variety of ideas naturally arose upon the subject; but as ultimate success could not be expected without great difficulties in the undertakings, the first step adopted was to engage good workmen; and as machinery and powerful water engines were required, Mr. Cole, who was then considered as the first man in that line (and held a contract under the Navy for

chain-pumps), was employed, not only in his own department to make the machinery, but also to assist in procuring some able men who had experience in sinking wells. He recommended a person named Wilcox, who afterwards gave proofs of his skill, and was a very good workman. Another man was also employed as a well-sinker, and the laborious part of the work was done by these two men. After having collected proper persons for the work, they were all consulted by Captain Page on the arrangement of a plan to proceed upon, and he endeavoured to apply the knowledge they had derived from experience in their several employments to public use, giving them all due credit for their judgment, but reserved to himself full power to controul what he disapproved, and to direct the work, as commanding engineer, standing alone in that capacity responsible to the Ordnance, with authority to proceed with the works of the wells according to his own judgment and decision. The subject was so difficult, that it soon appeared to be impossible to follow any regular system of ideas, however well arranged, as a fixed plan;

plan; and that, in proceeding with the work, expedients or remedies must be adopted, as difficulties arose, because the nature of them could not be foreseen. It was, notwithstanding, proper to establish some parts of a plan to commence upon, that seemed likely to lead to a good conclusion. It was in consequence determined to try to sink through the quick-sands, by the means of two circular frames of wood of different diameters, excavating within the small circle first, and lowering it progressively as the large circle could be formed above it. This part of a plan, as a commencement, was thought likely to answer: it was what the well-sinkers, and other persons employed, had recommended, and they were all confident that it would succeed. This plan having been so strongly recommended by practical men, and of long experience, Captain Page judged it proper to order a trial of it to be made. The Parade within the garrison of Sheerness was fixed upon for the place of the intended well, and the plan of the double frames was proceeded upon; it however soon appeared that it would not answer to a great

a great depth, as the quick-sands forced or blew under the small circle, and entirely destroyed the work, by filling the excavated part with sand, from a considerable distance under the Parade. Captain Page was not on the spot at Sheerness the day the accident happened, but was sent for. He found the well-sinkers, on his arrival, completely defeated in their expectations, and without any idea of power to repair the injury. It indeed but too clearly appeared that it was not possible to repair it, and that the double frames would not answer to a great depth. This attempt to make a well at Sheerness, where it was reported great expense had formerly been incurred by the Navy, in similar but unsuccessful endeavours, was, after the accident on the Parade, much blamed, and censure was not wanting in conversations held upon the subject, with regard to Captain Page, for hazarding an attempt in a work which had before failed, and while in the hands of the Navy. The Board of Ordnance did not entirely escape notice in the comments upon this subject in the House of Commons, where the Sheerness expenditure was termed "not a well

“ for fresh water, but a sink for the money
“ of the public.” Under these discouraging
circumstances Captain Page determined to
make a second attempt, but to do it with
material alterations in the plan, for a com-
mencement, and also in the manner of
carrying on the work, and without the
double frame to so great a depth. Another
situation was fixed upon, in Fort Town-
shend at Sheerness, there being no possibi-
lity of repairing the work on the Parade;
but as all circumstances that might arise in
the new mode of proceeding could not be
foreseen, he gave orders to Captain Hum-
frey, of the engineers, and Mr. Marshall,
the Ordnance overseer, not to proceed at
any future time with the work, or to suffer
the well-sinkers to do it, in his absence, if
any unforeseen difficulty arose, but to
suspend the work altogether till his arrival.
Mr. Marshall had further orders to send a
daily report of proceeding at the well by
the post, to Captain Page, when he was
employed at other places, that future
accidents might, if possible, be avoided;
and from that time, till the well was
finished,

finished, these orders were strictly attended to.

It was fortunate that such orders were given, as, without restrictions, other accidents of a serious nature would probably have happened, the weight of the quick-sands having several times splintered timbers of immense strength, and such as the workmen supposed equal to any weight. In these serious considerations the prudence of Captain Humfrey and Mr. Marshall, who were almost constantly on the spot, prevented many accidents by a judicious application of the orders they had received. Opinions upon the subject of the well, altered immediately after water was found in Fort Townshend; and letters, claiming rewards for having suggested the plan, were sent to the Ordnance, from men whose persons and projects were unknown to Captain Page, and could have no reference to the well at Sheerness. It was not generally known that the material parts of the plan had had no previous existence in arrangement to countenance such pretensions, but had been formed progressively, as

as the several parts were adopted into a general plan during the operation of the work. The failure in the first attempt on the Parade did not, however, arise from any real fault in the conduct of any one of the persons employed, but from too much zeal in expediting the operations, and from the manner of proceeding, and the double-framed circles not having answered. The objections had not occurred to any one till they appeared in the operation; it was, however, proved by the accident, that a more simple or less complicated plan would be preferable; and as nothing could exceed the good intentions and activity of all descriptions of persons employed, they constantly did as much as they could to the full extent of their judgment, in any measures that were adopted for the success of the undertaking. Captain Page did full justice to their conduct in his report and explanation upon the Sheerness well, dated 12th May, 1783. That explanation was seen and approved by Mr. Cole, and others, whose situation required such attention, before it was sent officially to the Master-General of the Ordnance. The reader may

see the plans and sections here referred to in volume 74th of the Philosophical Transactions of the Royal Society, of the year 1784, many years prior to the death of Mr. Cole.

The first endeavour of Captain Page, after the work was finished, was to serve all the persons who had been employed. If they have not been rewarded beyond the pay they received, it is matter of regret that their services have not been valued in the way they deserved.

The King did Captain Page the honour to approve of the military exertions he had an opportunity of making in the late war, and in consideration of the wounds he received upon service at Bunker's Hill, in America, his Majesty was pleased to reward him with a pension. He considered the title of knighthood to have reference to the same military services, and not to the well at Sheernes.

He has not received any reward on account of that well. He asked none, and therefore

therefore feels no disappointment; he considered what he did as doing his duty only, and no more than his country had a right to expect from him. All the works of the Ordnance at Sheerness, Harwich, and Landguard Fort, including the well sinking, were under the direction of Captain Page. Mr. Cole, Mr. Hooper, of Margate (who made the horizontal windmill at the Sheerness well), and also the well-sinkers, were under Captain Page's superintendance and orders, as the commanding engineer. They all deserved his best acknowledgments for their attention in their respective departments, and he gave them due praise for their conduct in his public reports. With regard to Mr. Cole, his great abilities were known and acknowledged by the country in general, and his memory will ever be respected as an able man and most worthy character.

*Explanation of the Wells which supply
Water for the Use of his Majesty's Dock-
yards, Garrisons, &c. of Sheerness,
Harwich, and Landguard Fort.*

St. Margaret's Street, 12th May, 1783.

My Lord, and Gentlemen,

I BEG leave to lay before your Lordship and the Honourable Board the plans and descriptions of the wells at Sheerness, Landguard Fort, &c. made in consequence of the experiments I recommended to be tried, to discover springs of water, and the subsequent order of the 19th March, 1781.

The success of those undertakings has greatly exceeded my expectations, which has arisen more from the favourable opinion his Majesty was graciously pleased to express of the project at an early period, and the countenance and support I received from your Lordship and the Honourable Board in conducting those works, than from any merit of my own as engineer, I presume it to be unnecessary for me to re-

peat to your Lordship and the Honourable Board, that my opinion since I was first honoured with the direction of the works on the Eastern Coast (in the year 1778) has been uniform, " That fortifications should not be carried on to any great extent without a plentiful supply of fresh water within the command of their cannon." How far an objection of this nature at certain places has been obviated, will appear from the annexed explanations; and should the experiments I have made become of more general use to the public, I shall consider it as the first reward and gratification to,

My Lord, and Gentlemen,
 Your most obedient,
 And most humble Servant,
 THOMAS HYDE PAGE,
 · Engineer.

*Right Hon. Lord Viscount Townshend,
 Master-General, and the Honourable
 Board of Ordnance.*

The

The Master-General of the Ordnance (Lord Townshend), in the year 1778, recommended to his Majesty, that the fortifications upon the Eastern Coast, including Dover, Sheerness, Landguard Fort, and some other places, should be repaired, and new works added where they might be found necessary toward a better state of defence. His Lordship foresaw the great objections to fortifications where proper supplies of fresh water could not be depended upon, under the command of the guns of our garrisons; and I had directions accordingly to consider the subject, and report upon the most probable remedy to so great a defect. This consideration produced the following letter from me, and the subsequent order in consequence from the Board of Ordnance.

“ London, March 4th, 1781.

“ My Lord, and Gentlemen,

“ The garrisons of Sheerness and Landguard Fort having no constant supply of fresh water that might not either be cut off or rendered very precarious,

“ should

“ should those places be besieged, it ne-
“ cessarily is of the utmost consequence to
“ have tanks, or other safe reservoirs,
“ that will contain upon calculation a suf-
“ ficient quantity to render the above-
“ mentioned inconvenience of less conse-
“ quence, which is, I presume, easily to
“ be effected: one of those garrisons con-
“ taining only such persons as would be
“ useful in its defence, and the other, a
“ very inconsiderable number in addition
“ thereto. It is therefore certain that a
“ proper quantity of water may be at all
“ times kept, proportioned to the daily
“ expenditure, to any length of time,
“ under exactly similar considerations
“ with the supply of men of war going
“ to sea. Upon this idea, I would beg to
“ recommend that a proper quantity of
“ casks be constantly kept full of water,
“ in the safest part of the garrison, as a
“ resource to be depended upon. I am,
“ notwithstanding, of opinion, that springs
“ of water might be found within the said
“ garrisons, by sinking wells to proper
“ depths, under the management of per-
“ sons used to such work, and would
“ there-

“ therefore recommend to the Honourable Board to order the experiments to be made as soon as possible ; the objects being so great, and expense trifling ; where little more than the hire of workmen would be required. Should this idea be approved, I can immediately procure every necessary assistance from workmen that have always been employed in such undertakings.

“ I am,

“ My Lord, and Gentlemen,

“ Your most humble Servant,

“ THOMAS HYDE PAGE,

“ Engineer.”

The Board's Order in consequence.

March 29th, 1781.

Ordered, That Captain Page be fully empowered to employ proper persons, and use all possible means, to find springs.

C. C.

The

* " The dock-yard and garrison at Sheerness were furnished with a very inadequate supply of water from Chatham, at the enormous expense of near two thousand pounds *per annum*, or occasionally from Queenborough; which could not be continued in case of a siege, and of course would render any defence of short duration. This had ever been considered as an unanswerable objection to the expenses of fortifying that place. Some attempts had indeed been made in former times to obtain water on the spot by sinking wells, but had failed; and success in such undertakings was at length despaired of, from the great difficulties they had met with in carrying their works through the salt water that penetrated by filtration through the different strata; and rendered a progress (according to their mode of operation) to any considerable depth impracticable. It is probable that the course of the river Medway may have undergone many changes, and have

* Extract from the seventy-fourth volume of the Philosophical Transactions of the Royal Society of the year 1784. Communicated by Sir Thomas Hyde Page.

had an outfall to the sea near the high ground of the Isle of Sheppey. The docks, garrisons, and other buildings, must consequently, for a considerable distance, stand upon very loose and bad foundations; which were found, upon sinking the well, to consist of mud, sea-beach, and quicksand, nearly to the present depth of the river Medway, and admitted a strong filtration of salt water, from which arose the chief difficulties in the former and late undertakings. This was the situation of Sheerness previous to the experiments which commenced the 17th of April, 1781; and Landguard Fort was not more eligible respecting water, as a place of strength: it was better supplied under any other consideration, a pipe being laid into the garrison from a good spring about two miles distant; but such is the disadvantage of situation, that, in case of attack, the spring-head would fall into the possession of the enemy, and the fort of course be deprived of its use. This was a serious consideration, under the necessity of fortifying a place of such local advantage, and general protection afforded by it to our trade, during

a war with Holland, or any of the northern powers. Harwich was judged by the commander in chief (Lord Amherst) to be a very proper station for a considerable part of the army in time of war with the Dutch (it being centrical), to furnish detachments to other parts of the coast that might be in danger; as also to cover a very useful harbour and increasing dock-yard; but his Lordship was sensible how far the health of the troops might suffer under the want of wholesome water in that neighbourhood; and I had accordingly from his Lordship particular directions to establish such supply for the camp to be formed there as might best obviate this objection to that situation; and the subsequent measures adopted with the approbation of General Rainsford, who commanded that district, perfectly answered every desirable end, as a temporary resource, until good springs were discovered within the camp. The inhabitants of the town of Harwich had, previous to this success, depended on rain for their supply; the wells formerly made being in general brackish, from the filtration of salt wa-

ter, and the neighbourhood to many miles distant was not better furnished, there being only stagnating waters in ponds or shallow wells, supplied from the upper surface of the ground ; and whether rendered bad by a mixture of copperas, of which great quantities are found on this coast, or other mineral, it was not such as could be given for the use of troops with any degree of prudence or attention to their health. I shall now endeavour to describe the experiments made use of at each place, beginning with the well at Fort Townshend, at Sheerness, which (with a reference to the plans which accompany this description *) will render the subject sufficiently intelligible."

King's Well, Fort Townshend, Sheerness.

" THIS undertaking was at first considered as a mere experiment, the probability of success being much against it. I, however, thought the attempt, where a dock-yard of

* The plans and sections alluded to are published in the 74th volume of the Philosophical Transactions of the Royal Society of the year 1784, by Sir Thomas Hyde Page.

great

great consequence was established, should be made, and carried as far as it could with a proper attention to economy in laying out the money of the public. This was my opinion, signified to the Board of Ordnance; I have already mentioned the answer thereto, expressive of approbation, and full powers to employ proper persons, and proceed upon the undertaking. Such previous steps seemed highly necessary, as, in all works of difficulty, great confidence is as much required as able workmen or good plans; and the favourable opinion his Majesty was graciously pleased to express publicly of the project at Sheerness, tended very much toward the final success. The countenance and support also of General Craig, governor of that garrison, encouraged perseverance in a work of such difficulty.

“ I employed a very ingenious man (Mr. Cole of Lambeth) as a chief person in this business, and received every assistance I expected from his experience and judgment in mechanics; and it is but justice to him to express, that the success of the work greatly depended upon his attention, and

the

the able workmen he procured from distant parts of the kingdom. The greatest acknowledgement is also due to the ability of Lieutenant Humfry, of the engineers; and Mr. Marshall, the Ordnance overseer, who were constantly on the spot, and carried my orders into execution with the greatest zeal for the success of the undertaking, as well as judgment. The mentioning those gentlemen's names, is (as well as justice to their conduct) to recommend harmony and mutual exertion in any future work of this nature: as without an equal attention in every one, I should greatly doubt success; even admitting the same plan to be in all other respects strictly attended to: and there would be great difficulty, and danger to the lives of the workmen, if carelessly carried on. The experiments in trying the different strata, and preparing the materials, commenced the 17th of April, 1781; the well in Fort Townshend was begun 4th June, the same year, and finished 4th July, 1782*. A circle of twenty-two feet diameter

* This plan differed materially from that which had failed in the first attempt on the Parade at Sheerness, being

meter was first marked out on the ground, and the space excavated to the depth of five feet; after which, pieces of wood, called ribs, upon the curve of a diameter twenty-one feet four inches, and about nine inches scantling, were placed to form a complete circle, within the excavated part at the bottom; above which, other circles of the same nature were placed, and supported by upright pieces of scantling; having short boards introduced by the intervals, which afterwards were pressed upon the circles, or ribs, between them and the exterior parts: these ribs, when united, formed one frame of wood from the bottom to the top, or rather higher than the excavated space, and prevented the mud on the upper surface, which was very soft, from falling in upon the workmen. In proceeding deeper, care was taken to prevent the sinking of the before-mentioned frame, by its own weight, in excavating parts only under it, till another circle was formed of pieces like the first, called ribs and uprights, with

being entirely without sheet-piling, and the double frames, which had been the chief cause of the accident.

boards

boards behind introduced. The distance between those circles was in the first or upper part of the work, about three feet; but as frequent difficulties increased, they were placed nearer, and in many parts joined each other, without any boards or uprights, as will more particularly appear in the section *: and continued through the whole of the wooden frame against an immense weight of mud, quicksand, and sea-beach, to the depth of thirty-six feet. The occasion of the circular ribs being nearer in some places than in others, arose from the greater or less quantity of salt water, that came through the sands, &c. and often rendered it impossible to sink under the frame more than the thickness of one of the ribs, without danger of blowing up, or of the mud, &c. giving way before such powerful streams of water, and thereby forcing itself into the bottom of the excava-

* The section alluded to is published in the 74th volume of the Philosophical Transactions of the Royal Society of the year 1784. That section shews that all the circular pieces, or ribs, had the same diameter, and at last formed one frame only, to resist the pressure, and without any sheet-piling.

tion,

tion, which, in sinking through very wet quicksand, &c. is much to be apprehended, and an accident of that nature would entirely destroy the work *. The section will shew at what depths the filtration of water was most dangerous ; and the difficulties at different periods may be estimated by the distance of the different circles, formed of ribs, from each other : and where they appear to join, it was not without the utmost efforts of labour, that the work could be carried on at the depth of thirty-six feet. The wood-work was finished, and, six feet deeper, a firm foundation of hard blue clay was discovered ; the several parts of the frame were then strengthened to prevent separation, and to resist the immense pressure of mud, quicksand, and loose sea-beach, which were supported by it. It must be observed, that the salt water, after proceeding thus far, came in very fast through all the joints of the frame, and external boards, in which holes were left on purpose to let the water into the well in different parts, that it might not be confined entirely to the bottom of

* Which had been the case in the first attempt upon the Parade at Sheerness.

the wood-work ; as from the weight upon one part only, there might have been danger of blowing up : a circumstance ever to be guarded against with the utmost caution *. The frame being made of sufficient strength, and the workmen able by continual drawing with four thirty-six gallon buckets, to keep the bottom of the well dry enough to proceed further, the greatest difficulty seemed to be overcome. The next process was to cut off, or stop out, the salt water entirely ; to effect which, a smaller circle was described at the bottom of the excavation, upon the hard clay already mentioned, of the diameter of eight feet in the clear, or inside of the circle : round which, a circular frame of wood was laid, and a brick steening, of two bricks or eighteen inches thick, in terrace, raised gradually to the top of the well † ; whilst, as it proceeded upwards,

* And which had not been attended to in the work that failed upon the Parade.

† This frame was for the foundation of the brick steening, and not to resist the quicksands, &c. The King was at Sheerness a little before this progress in the undertaking, and gave orders to Capt. Page to proceed

wards, the space between the back of its steening and the wooden frame fixed six feet higher, was filled with well-tempered clay four feet thick, and carefully rammed, during this operation, and raisng the brick-work with the clay behind it, the water continued to run over the whole work into the centre of the well, now reduced from twenty-one feet four inches, to eight feet diameter; and was constantly drawn out so as to leave the sides sufficiently dry for the workmen to raise them, until they had reached the top, and consequently, as this work was water-tight, completely cut off the filtration from the sea. Precautions having been taken to prevent the danger of blowing at the bottom, the next proceeding appeared more simple; but great care was still necessary to avoid damaging the foundation of the works already done, as the least crack might have again introduced the salt water. A smaller circle than the last was therefore described, and ribs forming circles of wood, raised some feet higher

eed in the work to the utmost extent, or as far as a possibility of ultimate success could justify the attempt to discover a spring of fresh water.

within the brick-work ; and others of the same form, were sunk to the depth of eight feet below the bottom ; upon which the several works already described rest *. After this a course of bricks was carried up within the last-mentioned ribs, or circles, upon a diameter of six feet ; whereby they became enclosed and joined with the first-mentioned brick-work ; having the clay wall, and wooden frame, pressing behind them upon larger dimensions. In sinking down, small curbs were, at certain depths, as will appear in the section of the work, placed to support the steening, which consisted of two stretching courses of bricks laid separately and keyed into the clay, or back part of the brick-work, by rough pieces of stone, flints, &c. to prevent a slipping or lowering of the steening by its own weight. The work was carried on from this period without any material difficulty, or difference in the clay, except the very extraordinary discovery of a piece of a tree, at the depth of three hundred feet from the top of the well, which is represented in the section ; until

* This was an operation of precaution, not of difficulty, and merely to secure the foundations.

the appearance of water at three hundred and twenty-eight feet deep, by a small mixture of sand and clay, with ousing of water from it: and at three hundred and thirty feet deep, upon boring, the whole bottom of the well blew up, it being with great difficulty the workmen escaped the tørrents of water, which was mixed with a quick-sand, that rose forty feet from the bottom of the well. The water rose in six hours one hundred and eighty-nine feet, and in a few days, within eight feet of the top of the well. It has since been carefully analyzed by a chemist, and found perfectly good for every purpose, and it is presumed, the quantity will be equal to every demand of public and private use at that place; there having been, ever since it was discovered, a constant drawing, and the water has not been lowered more than two hundred feet. It is proper to remark that the water is of a very soft quality, and upon being drawn, has a degree of warmth unusual in common well water: it remains yet to be determined from whence that warmth proceeds; but as it is proved wholesome, the circumstance is fortunate for the troops

of the garrison; and they will not be so liable to the complaints that are frequent among troops (as often happens at Dover castle), arising from the use of very cold well water."

King's Wells, at Landguard Fort,

"They were begun and finished in the year 1782. The peculiar situation of this Fort made it very unlikely that springs of fresh water could ever be found, there being great reason to think that the outfall of the Ipswich and Manningtree rivers, which unite before they reach the sea, was formerly on the Suffolk side of the Fort (which is now on the Essex side); and as the garrison, in ancient writings, is described to have been built on the Andrews Sand, there appeared little probability of any filtration of water, except that of the sea. It however seemed proper to try the possibility of sinking through it, to find a hard bottom similar to that discovered at Sheerness; fresh water being of vast consequence to the defence of the place. The work was accordingly

cordingly begun ; but about the same time, in making the excavation of a ditch for one of the batteries, at a very few feet from the upper surface of the sand, a small quantity of fresh water was perceived, and it was chance that led to the discovery of its freshness, from one of the labourers happening to taste it. This circumstance was reported to me by Mr. Roberts, the adjutant of the works ; and we, upon examining further, found that the quantity of water, upon sinking lower, increased, and appeared perfectly fresh. I then ordered a well to be sunk to this depth, at a more convenient place, for the use of the garrison. A like appearance of good water was discovered, and the quantity was so great as to render it very difficult to keep the bottom of the well, at twelve feet deep, dry enough to sink further. Notwithstanding, every exertion was used ; and with great labour, a well could only, at last be sunk to the depth of low-water mark, at spring tides, about eighteen feet from the upper surface of the sand ; when, to the surprise of every person, the water that rose from the bottom became on a sudden en-

tirely

tirely salt. This put an end to the work for some time; and as it seemed impossible to penetrate deeper, I then considered the matter very differently from my first idea; and though the impossibility of having a deep well clearly appeared, there remained a prospect of a sufficient supply of good fresh water. It may now be necessary to recollect, that at a very few feet from the surface (eight feet), good water had been found, which continued in great quantity almost to the spring tide low-water mark: after which, upon a lower line, salt water had appeared. I therefore directed sand to be thrown in again, to bring it a little above what had been the lowest fresh water depth, twelve feet from the upper surface, and then drew the water out that had been mixed. After this the filtration into the well became again perfectly fresh, and in equal quality to the first appearance. This was therefore fixed as the greatest depth (twelve feet), and another well sunk at forty feet distance, with a horizontal brick drain, having holes left in the sides for filtration (as described in the section),

fection *), to collect the water: and the bottoms of both wells were secured with hard materials, that the whole supply of water might be reduced to the drain; which is constructed to prevent as much as possible the mixture of sand with the water, and answers the desired end. This success arose from various unexpected circumstances; but I am yet at a loss for the cause of the fresh water, or whence it comes. I conceive that there is a certain distance from the sea, upon every sandy shore, to which the salt water penetrates, where it is forced whilst the tide is at its greatest height; and that such water, when so far pressed into the sands, has an action back towards the sea again, as the tide falls, and continues to have it until another tide makes it revert. This may account for the filtration of salt water a certain way into a country, and that further, through probably higher surfaces, there may be fresh water in the same continuation of sands: and the sepa-

* Seventy-fourth volume of the Philosophical Transactions of the year 1784.—It is therein, through mistake, called the Harwich well. It ought to have been called the Landguard Fort well.

ration determined to a great accuracy. Whether this action of salt water in the sand by friction can render it fresh, or of a less degree of salt, I will not pretend to judge: I presume the contrary, but am, even under that idea, at a loss to know how so much fresh water gets into the sand at Landguard Fort, it being so entirely separated from the springs of the country. It is evident upon a full investigation of the subject, that the sea, to the height of low water, will penetrate a vast distance into sands, by filtration, and to that height only, it having so far a constant pressure, and no reaction. The water, therefore, being once in the sand, can never return by the same passage, while the cause of entrance remains: whereas in the higher surfaces, the rise and fall of tides must keep it in constant movement, and the distance of filtration will bear a proportion to the duration of pressure which gave it original motion. It is probably not so easy to account for a body of fresh water being to the depth of 12 feet in the sand, and that in the same line, a few feet deeper, the water should be entirely salt, and that they should not mix together. Whether the greater specific gravity

vity of the salt water is sufficient to prevent a mixture with the fresh, upon a higher line, I cannot venture to say; but the fact of there being a separation is beyond a doubt, and the depths may be ascertained to a degree of great accuracy. However this may be accounted for, the discovery at Landguard Fort is of very great consequence to that garrison; and there is reason to think, that in similar situations, where water is wanted, an attention to what has been already explained may be found of great use."

King's Wells, at Harwich,

" Were begun the 6th of May, 1781, upon General Rainsford's taking the command at that camp, and finished the 29th of September following.

“ The wells in this neighbourhood, as has already been observed, being very shallow, and only depending on springs from the upper surface of the ground, have but little water in the summer season, and the qua-

lity of it very bad. The best of the old wells was in the rear of General Rainsford's camp, and was thought of at first for the use of the troops; but he prudently declined that supply. It was imagined, as the water from the upper surface was of a bad quality, that the most likely way to obtain a better spring was to sink a well from higher ground, and to endeavour to penetrate through a rock, which lay a few yards under the level of the country, although the operations might be tedious, upon the chance of cutting a spring of better water, unconnected with the land drains. The experiment answered in every respect, as there was not a drop of water to be found till the rock was entirely cut through, when, upon finding a considerable quantity of moist sand, and boring into it, a plentiful spring was discovered, which has supplied the troops ever since with very good water; and it is probable this supply (the spring being very powerful) will be found equal to every demand for public or private purposes, in the driest seasons. After this success, as matter of curiosity, an old well was made deeper by excavating through the

the rock, when also a good spring was found; but as that well had been originally sunk from low ground, a great deal of the bad water from the upper drains mixes, and gives it a disagreeable taste,

"The plans and sections will describe the manner of making those wells sufficiently *. I have chiefly dwelt on the descriptive part, to recommend (where it is apprehended any mineral, or drain, from the upper surface of lands, by mixing in wells, may hurt the water) the sinking from the heights, as there are few countries where very good water may not be found, by a proper attention to locality in the undertaking †."

THOMAS HYDE PAGE,
Engineer.

* Copies of those plans and sections were given by Capt. Page, in the year 1784, to be published by the Royal Society, but were, through a mistake, omitted in their Transactions of that year. The original plans are now in the possession of Capt. Sir Thomas Page.

† This account of the Sheerness, Harwich, and Landguard Fort wells, was published with the approbation of Capt. Page, in the year 1784, by the Royal Society, vol. 74 of their Transactions.

To the Comptroller of the Navy.

Upper Fitzroy-street, April 14, 1795.

SIR,

I HAVE great pleasure in complying with the desire you have honoured me with, to have my opinion upon the supply of water for the dock-yard, from the well that was sunk at Sheerness, under my direction, in the late war.

The great want of water for the use of the dock-yard and garrison, with the heavy expense of the usual supply from Chatham, as well as the impossibility of making Sheerness a place of strength, without water within the line of the fortifications, induced me to propose the undertaking, which fortunately was attended with success, by affording not only a powerful supply of water, but that of the best quality.

The work was attended with much difficulty, but the object was of sufficient importance to encourage exertion; and his Majesty having seen the undertaking during the

the critical part of the operation, was graciously pleased to approve of the endeavours then used, and to direct that all possible means should be tried to ensure success.

The quality of the water, after many years experience, is found to continue perfectly good; and the power of the spring such as would, I believe, render it impossible to draw the well dry, or within many feet of the bottom: but it is with regret that I am under the necessity of informing you, that until the whole of the intended plan is finished, the navy cannot receive that benefit they have so long been in want of. The machinery of the well is made to draw water either by wind or horses; in calm weather by the latter, but never to have the two powers of wind and horses used at the same time. This operation should be under the care of a skilful man, to reside on the spot. An uniform mode of drawing water should be observed; neither to have it too suddenly lowered by the wind, or the operation to cease altogether for want of horses, in a calm; and the drawing of water should be in the night, as well as in the

the daytime; the object certainly being of sufficient importance to warrant the expense of an extra watchman. The part of the plan intended for the conducting of the water from the well to the dock-yard, has not yet been attended to in the way I recommended. A main of iron pipes should have been laid from the well to a large reservoir in the dock-yard, calculated to hold as much as any great emergency or demand of the service could require. It should be kept constantly full, or as nearly so as possible, to answer any sudden demand: and all other supplies of water, whether to the navy or garrison, should be by the means of iron pipes from that chief reservoir, which would cause a constant stream through it, and prevent stagnation, or any chance of injury to the water. Casks in boats, for the use of the King's ships, might be filled from that reservoir without being landed, and many other objects of convenience and comfort given to the navy, which they seem now in want of. I am of opinion, that a judicious arrangement of the supply would prove the well to be sufficient both for the navy and garrison, as well as inhabitants of every description

